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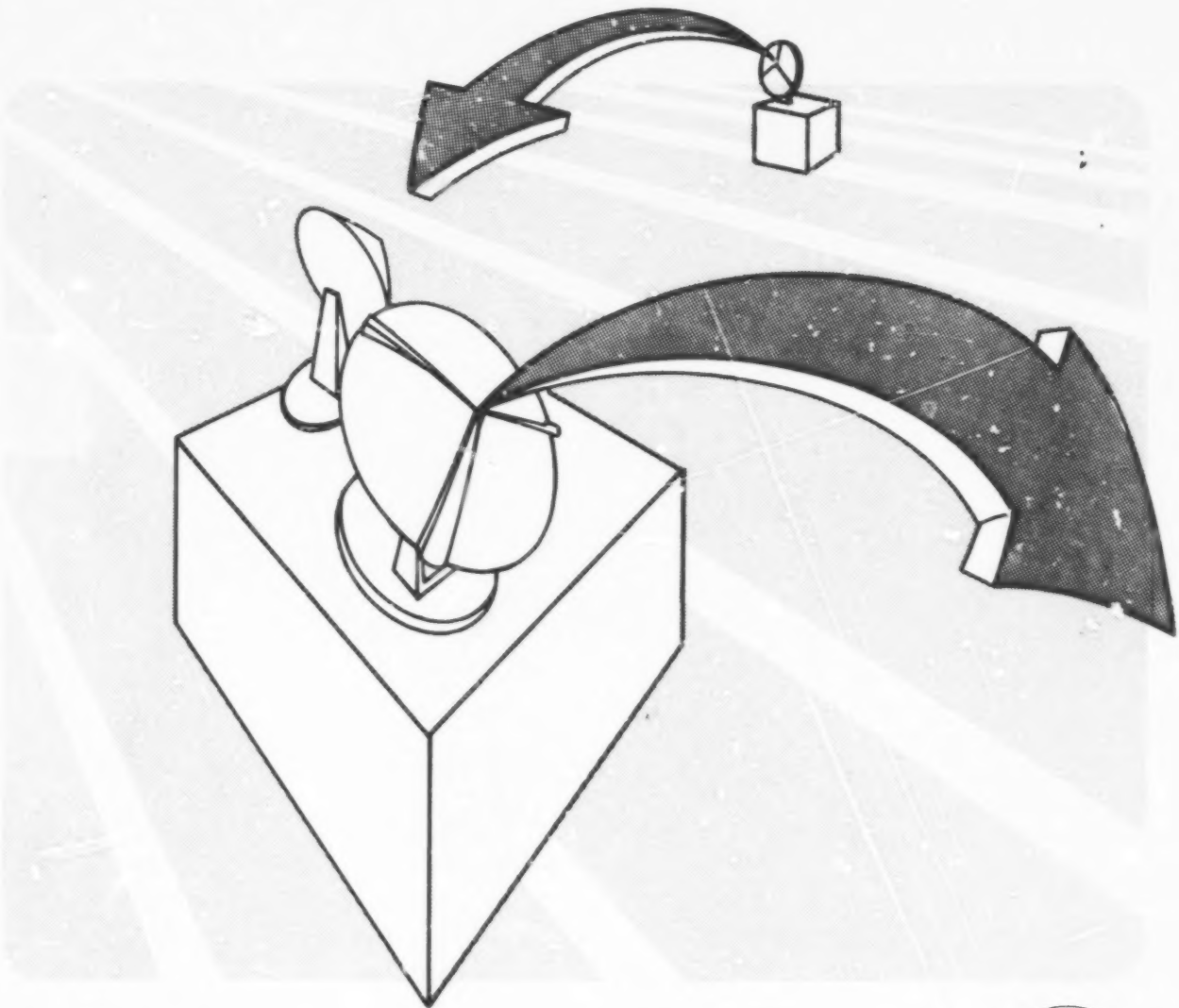
# Maintenance Manual
# Microwave Transmitters and Receivers



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# MAINTENANCE MANUAL

# MICROWAVE TRANSMITTERS AND RECEIVERS

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Federal Emergency Management Agency

Maintenance Manual
Microwave Transmitters & Receivers

## Introduction

The purpose of this manual is to guide you on how to maintain a microwave transmitter and receiver. The information in this manual is only a **supplement** to the recommended maintenance information in the service manuals provided by the manufacturers of the equipment. **Always follow the maintenance procedures outlined in the manufacturer's manuals.** This manual will help you understand why maintenance is necessary. This manual will also be helpful if the manufacturer's maintenance manuals are not immediately available.

## Microwaves and Their Uses

Electromagnetic waves are the way in which radiant energy, such as heat and light, is carried through space. One special variety of these waves is called microwaves. Microwaves are very short and have high frequencies, from about 3 to 300 GHz.

Microwaves are widely used in communications, especially by the telephone industry. A microwave signal is very directable and a large amount of information can be compressed into one frequency. These advantages are dampened by microwaves' inability to bounce off objects like radio waves and the expense for special equipment to send and receive microwaves.

## Description of a Microwave Transmitter & Receiver

**A microwave transmitter consists of a microwave generator, a power amplifier (if necessary), a circuitry board, a modulator to modify the microwaves with information and an antenna system.**

### Transmitter

**The microwave generator is the heart of the microwave transmitter. There are several types of generators, including the traveling wave tube, the klystron, and the Gunn oscillator. The traveling wave tube** can be tuned over a wide range of frequencies. It is also a very sensitive amplifier, producing little noise. It delivers much less power then other generators at similar frequencies. **Klystron tubes** generate microwaves up to 400 GHz and are much more

powerful than traveling wave tubes. **The Gunn oscillator** is an example of a solid state generator currently in use. Its small size, low cost, and ruggedness make it highly attractive for use at higher frequencies (above 8 GHz). Its power output is only limited by its inability to remove heat efficiently.

**Antenna system**

The main purpose of the microwave antenna is to capture the incoming signal, and then to shape the transmission so that it is aimed accurately to the next station. Microwave antennas bear little resemblance to antennas used for ordinary radio transmissions. The antennas are highly directional which helps overcome some of the technical limitations with microwave receivers and transmitters.

The antennas appear in several forms. The most common shapes are the horn and parabolic antennas. The horn antenna directs the microwave signal much like a megaphone directs a singer's voice. The flaring walls of the horn antenna acts as a large guide for the microwave signal. Parabolic antennas are dish-shaped. They are used as reflectors, focusing the microwaves in one direction. The antenna's shape is related to its ability to focus a signal in a particular direction; increasing the diameter of the antenna is one way of improving this focus.

**Microwave receiver**

Microwave receivers are very sensitive. Sensitivity is a way of expressing how well a receiver can pick up weak signals; what is the weakest signal a particular receiver can detect? One way of measuring this sensitivity is to measure the value of a signal in comparsion to the noise level that a receiver generates. Noise is the major limiting factor for a receiver. Noise is generated by heat. Recievers reduce this thermal noise by using incoming energy more efficiently within the receiver's electronic components. Equipment cost is generally tied to this efficiency and and enhanced sensitivity.

There are other special components that make up a microwave station, of which a receiver and transmitter are just one small part. Amplification of the signal is accompliished by the antenna system head amplifer. It is usually positioned close to the center of the dish or at the base of the antenna's mast. Ordinary wire is not used to transmit microwaves from one point to another within the station. Coaxial cable and waveguides are used to transmit the signals once they are received.

Coaxial cable consists of an inner wire and a layer of insulation surrounded by an outer conductor. The microwave actually travels along the insulating space between the two conductors. Waveguides are carefully machined rectangular or circular pipes through which the microwave signal travels. Propagation of the signal is achieved by alternating the electric and magnetic fields of the wave. Altogether, these components help move the signal within the station once it is received, and speed the ultimate transmission of signals.

## Preventive Maintenance

To ensure that your microwave receiver and transmitter work in an emergency, you should develop a program where you **regularly check your equipment to spot small troubles before they become big problems**. A program of coordinated monthly, semiannual and annual maintenance checks prevent serious problems from suddenly happening.

**Routinely clean the equipment. Inspect all cables. Examine the antenna tower for problems. Check for frayed connections and loose bolts and parts.** These checks are not normally mentioned in manufacturer's manuals, but can lead to more serious problems.

### Equipment and Spare Parts

**Special instruments capable of measuring very high frequencies are necessary.** Ordinary mechanical and electrical tools are also needed. **You will also need instruments that are capable of measuring low amounts of power.** The cost of this equipment can be high; you may want to coordinate your maintenance efforts with other agencies.

**Make a list of spare parts.** Solid-state equipment such as microwave transmitters and receivers have few user serviceable parts. The following table gives you an example of a spare parts list for a typical microwave transmitter and receiver.

Spare Parts: Microwave Transmitter & Receiver

| Names of parts | Quantity |
|---|---|
| oscillator | 1 |
| hardline | 50 ft. |

(Note: hardline is a special type of coaxial cable, with a solid outer shield)

**Safety**

**Microwaves are dangerous. Microwaves are intense forms of energy which may inflict burns to the skin and cause other injuries, especially to the eyes.** Only a qualified electronics technician should attempt to repair any serious electrical problems. **Follow safety precautions outlined in maintenance manuals provided by the manufacturer. Exposure should be limited to no more than 10 milliwatts per square centimeter ($10mW/cm^2$).**

**As Needed Maintenance Checks**

1) After each windstorm, check antenna alignment.

**Monthly Maintenance Checks**

**1) Clean radio set to remove moisture, loose dirt, fungus, etc.**

**2) Check all cables for evidence of chafing, cracking or excessive strain.** Check all electrical conductors for dents, cracks or improper mating. Check connector cap & fuse cap for security.

**6-Month Maintenance Checks**

**1) Check all transmission line cables or waves guides for integrity.**

**2) Inspect all terminal boards for loose connections and cracks.** Tighten loose connections and replace damaged terminal boards.

**3) Operate all component slides.** Slides should operate smoothly without excessive noise or binding.

**4) Inspect grounding system, including the grounding of the tower.**

**5) See that all air filters are in place and clean.** Replace and/or clean air filters as necessary.

**12-Month Maintenance Checks**

**1) Inspect exposed metal for rust, corrosion and bare spots.** Repaint as necessary.

**2) Inspect oscillator for signs of overheating.**

**Corrective Maintenance: Troubleshooting**

Some equipment malfunctions may be discovered during inspection or use of the microwave equipment. Contact a qualified electronics technician to inspect the equipment. You may also want to perform the tests on the following tables to locate, and possibly correct, the problem.

**PLEASE NOTE: This manual does not attempt to list all possible malfunctions that could occur nor can we suggest all possible remedies. Consult with an electronics technician or examine manufacturer's manuals, if available, if a malfunction is not listed or it is not corrected by a prescribed procedure.**

## Corrective Maintenance: Microwave Transmitters & Receivers (part 1 of 3)

| Malfunction | Possible Cause | Recommendation |
|---|---|---|
| 1. Unit does not operate; "power" light does not glow | ■ burned out fuse | ■ replace fuse |
| | ■ open cable | ■ check voltage with VOM. If no voltage, check and repair cable. |
| | ■ on-off switch defective | ■ if voltage is is present with switch in either position, replace control head |
| | ■ pilot light | ■ replace old bulb |
| 2. Unit does not operate; "power" light glows | ■ short within unit power circuits | ■ replace radio with a spare |
| | ■ short within unit | ■ check with ammeter. If current higher than rated, replace unit with spare. |
| 3 Unit transmits but does not receive | ■ squelch set too tight | ■ adjust squelch control. |
| | ■ defective rf amplifier tube (if used) | ■ try new tube. If operation not restored, replace unit. |
| | ■ defective relay | ■ short antenna & receiver input contacts. If operation restored, burnish & adjust relay contacts. |

## Corrective Maintenance: Microwave Transmitters & Receivers (part 2 of 3)

| Malfunction | Possible Cause | Recommendation |
|---|---|---|
| 4. Unit receives but does not transmit | ■ PPT switch defective or mike cable open | ■ try new mike or short PTT terminals at mike receptacle with test lead. Monitor transmitter output with an rf wattmeter or field strength meter. If operation restored, replace mike with spare or field strength meter, or repair PTT switch or mike cable. |
| | ■ defective tube (if tube used) | ■ try new tubes, one at a time. If operation not restored, replace unit with spare. |
| 5. Operator controls do not work properly | ■ defective radio set or loose knobs | ■ check knobs for tightness; tighten or replace as necessary. Tighten setscrews that engage collar and flattened shaft. |
| 6. Radio set does not tune to desired frequency | ■ defective radio set | ■ remove and replace radio set |
| 7. Excessive hum heard while receiving | ■ radio set defective. Defective inter-phone system. | ■ check interphone system. Remove & replace radio set if necessary. |

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## Corrective Maintenance: Microwave Transmitters & Receivers (part 3 of 3)

| Malfunction | Possible Cause | Recommendation |
|---|---|---|
| 8. Radio set inoperative (no sidetone or signals heard) | ■ primary power circuit breaker or fuse open. Electrical connector not properly mated. Radio set defective. | ■ check primary circuit breaker or fuse, or radio set fuse; and reset or replace. Check electrical connection for proper mating. Remove & replace radio set if necessary. |
| 9. Audio is distorted | ■ defective interphone system. Radio set defective. | ■ check interphone system and cables. Remove and replace radio set if necessary. |
| 10. Radio set will transmit but not receive | ■ squelch improperly set. Interphone system defective. | ■ adjust squelch. Check interphone system. Remove & replace radio set if necessary. |
| 11. Radio set works on some frequencies but not on others | ■ radio set defective | ■ remove and replace radio set |
| 12. Reception & transmission weak | ■ antenna system or radio set defective | ■ check antenna cable and connectors at back of radio set and at antenna. Replace radio set if necessary. |